Swimming and grommets[1]

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Summary: The dictum that patients who have plastic ventilation tubes (grommets) inserted in their tympanic membranes should not go swimming is questioned. A theoretical assessment is made of the pressure necessary to push water through a grommet. This value is compared with practical observations. These values are discussed with reference to chemical and bacteriological hazards and it is concluded that water is unlikely to enter the middle ear in surface swimming, and even when diving underwater the chances of setting up an otitis media must be small.

Introduction

Plastic ventilation tubes (or grommets as they are frequently known) have been used in the treatment of middle ear effusions since they were introduced by Armstrong in 1952 (Armstrong 1954). Many otolaryngologists advise patients against getting water in their ears with grommets *in situ,* and particularly against swimming. The concern is that water will pass through the grommet and initiate an otitis media. It is certainly known that aural discharge does occur in patients with grommets (Armstrong 1968), but not whether it is due to water entering the middle ear. A solution to the supposed problem was put forward by Castelli *et al.* (1976), who described a grommet with a membrane that allowed air but not water to enter the middle ear.

More recently there have been two reports that questioned the traditional advice. Jaffe (1981) reported a low incidence of aural discharge in those patients who were allowed to swim provided they put antibiotic drops in their ears after swimming. Chapman (1980) studied two groups of children; one chose to swim when they had grommets, and another did not. He found an equal incidence of aural discharge in the two groups.

The purpose of the present study was to establish what happens to water when it enters the external meatus of a patient with a grommet *in situ.* The first question asked was 'What hydrostatic pressure is necessary to push water through a grommet?' A theoretical answer was calculated and then compared with observed results.

Theoretical consideration

Consider a grommet lying in a rigid membrane. The pressure necessary to push water through is at a maximum value when the meniscus is pushed flat and is given by the formula

$$P=\frac{2\gamma}{r}$$

where P = pressure; γ = surface tension of water (76 dyn/cm^2); r = radius of grommet (standard grommet diameter = 1.1 mm). The hydrostatic pressure may also be expressed as

$$P=h\rho g$$

where h = height of column of water; ρ = density of water; g = acceleration of gravity (981 cm sec^{-2}), and thus

$$hg\rho=\frac{2\gamma}{r} \text{ or } h=2.8 \text{ cmH}_2\text{O}.$$

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This then is the value if the grommet lies in a rigid membrane. The tympanic membrane is of course not rigid. Zwislocki (1957) showed that it moves until about a 2% pressure gradient exists across it. This movement is graphically demonstrated in the standard impedance audiogram (see Figure 1).

A 2% pressure gradient roughly equals 200 mmH_2O and indeed there is little movement beyond that point. Also up to about 100 mmH_2O the graph is roughly linear. One might then assume that the drum head is moving like a free piston in the range between 0 and 100 mmH_2O and that as the volume of the middle ear decreases, its pressure increases proportionately. Suppose then a grommet lies in the ear drum with water in its lumen. This makes the drum whole, and as long as the drum moves freely the middle ear pressure = external pressure. As the drum becomes fixed a pressure gradient builds up across the meniscus and when this reaches 2.8 cmH_2O, water will flow into the middle ear.

If 100 mm of water is the point at which the drum starts to become fixed, then the total pressure necessary to push water through the tympanic membrane is $100+28 = 128$ $mmH_2O = 12.8$ cmH_2O. If the point of almost total fixation is reached before this occurs, then the value is $200+28=228$ $mmH_2O=22.8$ cmH_2O.

We therefore expected to find that water could be seen to pass through the grommet in an ear drum between about 12 and 22 cmH_2O. This would crucially depend on (1) pure water, and (2) a mobile ear drum.

Methods

Two sets of observations were made.

In vitro: A grommet was sealed in a stent membrane and surrounded by a wide bore glass tube lying above it (Figure 2). Water was then added slowly and carefully down the side of the tube. The maximum height (h) of the column of water achieved in this fashion was recorded.

In vivo: A drop of sterile water was placed on a grommet lying in an ear drum. The pressure in the external auditory meatus was then raised and the value P noted when the water was seen to pass into the middle ear. For these measurements, a Siegle's speculum modified by the addition of a flat glass lens was used in conjunction with the operating microscope. The pressure was altered manually with the bulb on the speculum which was also connected to a water manometer.

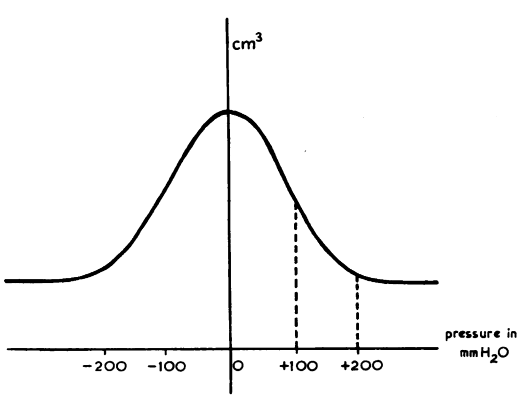

Figure 1. Normal tympanogram showing the approximate change of volume in the external meatus (impedance in cubic centimetres) against the change in pressure (mmH_2O) in the external meatus

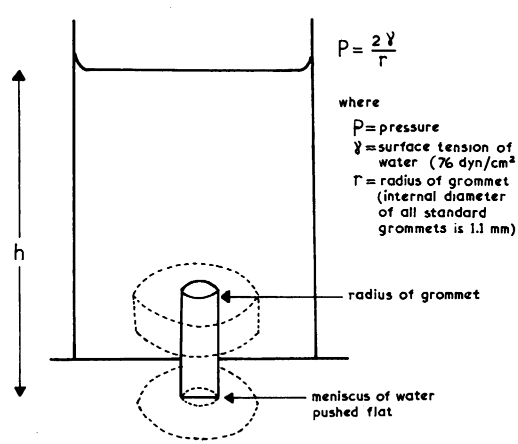

Figure 2. Diagram showing the parameters affecting the threshold pressure P at which water will start to flow through a grommet

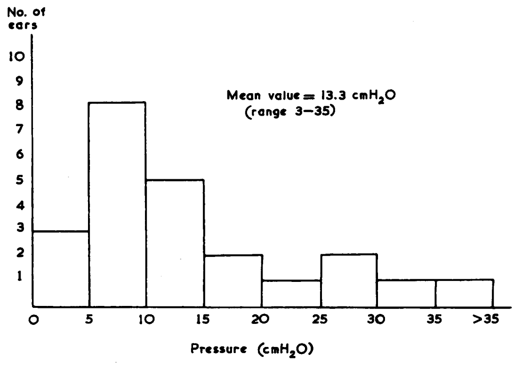

Figure 3. Frequency distribution of pressure values necessary to push the water through a grommet *in vivo*

Seventeen patients were examined. Among these, 21 ears were reliably assessed to give a value for P. In 12 cases patients were measured under general anaesthesia, and in 9 cases the patients were awake. There was one adult, all the rest being children between the ages of four and seven years.

Results

In vitro: The value for h, the height of a column of water supported by a grommet in this way, was found to be 1.8 cmH_2O. It was felt that this lower than expected result was produced in part by impure water and also by the inertia of water running down the glass tube.

In vivo: The mean value for P in all ears studied was 13.3 cmH_2O (Figure 3). The results ranged widely from 3 to 35 cmH_2O (Table 1). Interestingly the mean value falls very near the predicted value of 12.8 cmH_2O. Although the scatter of the results is wide the modal value is probably a little lower than the mean, in the order of 9–10 cmH_2O.

Having observed the water traversing the grommet other observations can be added:
(*a*) Of those patients awake, only one complained of any discomfort on water entering the middle ear – the adult.
(*b*) Also in the conscious patient, water lying on the grommet just stayed there for at least three minutes. It did not enter on swallowing and was very readily displaced by a Valsalva type of manoeuvre.
(*c*) As pressure was increased in the external canal it could be observed to move the ear drum in preference to the water. This was especially true in patients with a flaccid pocket which moved freely, the water remaining stationary. These patients all gave high results for P.

Table 1. Pressure thresholds at which water flowed through grommets in 17 patients

Patient	Age (years)	Pressure threshold P (cmH_2O)	Patient	Age (years)	Pressure threshold P (cmH_2O)
1	45	3.2	10	6	12.6 (right)
2	6	10			8.4 (left)
3	5½	8	11	5	6
4	6	13	12	6	13.4
5	7	6	13	6	35
6	4½	9	14	4	29.6 (right)
7	6	10			27.6 (left)
8	7	3(right)	15	6	15
		3(left)	16	6	20
9	4	9	17	5	20.2 (right)
					18.2 (left)

Mean value 13.3 cmH_2O (range 3.2–35 cmH_2O)

(*d*) The converse was true. Any crusting on the drum reduced its compliance and low readings of P were recorded.

Discussion

It would seem from the foregoing that water does not enter the middle ear via a grommet as easily as might initially be thought. In the case of normal surface swimming, bathing and hairwashing, it is probable that water does not enter the middle ear in most patients. Younger patients who are learning to swim, in particular, tend to keep their heads above water. However, it is those children who dive and swim underwater who might seem to be at risk of water entering the middle ear and possibly setting up a middle ear infection. But what degree of contamination is required to set up an otitis in these circumstances?

Castelli *et al.* (1976), in their paper describing the membrane lumen tube, originally investigated it in cats with tied Eustachian tubes. As part of their tests, a pseudomonas solution was introduced into the external meatus of both cats with normal lumen tubes and cats with Castelli grommets *in situ*. Ten out of ten cats with standard grommets succumbed to otitis media. However, in a total of 14 ears with the Castelli grommet this solution was sufficiently virulent to cause an erythematous reaction in the external meatus – in short, otitis externa. The solution used was in the concentration of 10^3 organisms/ml. The pressure used to introduce this through the grommet was 40 cmH_2O. However, such levels of bacterial contamination are not frequently found deep enough to submerse the head! They may be found in bath water where gram-negative organisms like pseudomonas, proteus, klebsiella and *E. coli* may be cultured (Ayliffe *et al.* 1969). Concentrations as high as 10^6 organisms/ml may be found (Ayliffe *et al.* 1975). It is interesting that Jaffe (1981) told his patients to use drops after swimming, but not to bother after bathing or hairwashing. However, none seemed to suffer from this omission. As regards swimming pools, the level of chlorination should preclude high bacterial counts (DHSS 1969), but chlorine is an irritant. There are no direct data on this with regard to the middle ear mucosa. However, it has been reported in relation to the respiratory mucosa and is related to length of exposure (Mustchin & Pickering 1979). Other possible irritants are soaps and detergents. Not only are they irritants, but will also increase the likelihood of water passing through the grommet.

We would recommend that there are no theoretical grounds for stopping patients from swimming when they have grommets *in situ*. Water will probably enter the middle ear when swimming under water. However, if this is not prolonged, irritation may be minimal and an inflammatory response may not become evident. The situation that probably should be avoided is submersing the head in bath water in order to rinse off shampoo. Not only will the water traverse the grommet, but it may well contain a significant number of organisms.

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